difications of this dentition resemble those of the latter genus in the retention of the premolar, after the last true molar has come into its place, and in the superior size of the first, as compared with the second and third incisors. He then described in detail the sockets of the incisors, and the form and conditions of the molar teeth, which are highly characteristic of the marsupiality of this huge and most strange extinct quadruped. The cranial characters, which were next described, equally elucidate this affinity. The peculiar facial bones were then described in detail; that portion in advance of the orbits forming, as it were, a short pedunculate appendage to the rest of the skull, increasing in a remarkable manner in both vertical and lateral extent as it approaches the muzzle, but not offering any evidence of having borne a nasal horn, as thought to be probable by Mr. Macleay. The cavity of the nose is divided by a bony septum,—a character which Prof. Owen has lately found to exist also in a rare species of living Wombat—to a much greater extent than in other known marsupials. Wholly concurring in Mr. Macleay's conclusions as to the marsupial nature of the fossil in question, Prof. Owen does not think that it exhibits evidences of a generic distinction from *Diprotodon*. The Professor suggested, however, that probably the lower jaw, when found, may show some peculiarities of dentition and proportions similar to those on which he has founded the genus *Nototherium*.

ROYAL INSTITUTION OF GREAT BRITAIN.

March 12, 1858.—The Duke of Northumberland, K.G., F.R.S., President, in the Chair.

On the Lowest (Rhizopod) Type of Animal Life, considered in its relations to Physiology, Zoology, and Geology. By William B. Carpenter, M.D., F.R.S.

Among the unexpected revelations which the modern improved microscope has made to the scientific investigator, there is perhaps none more fertile in interest than that which relates to the very lowest type of animal existence; from the study of which both the Physiologist and the Zoologist may draw the most instructive lessons, whilst the Geologist finds in it the key to the existence of various stratified deposits of no mean importance both in extent and thickness.

Though the doctrines of Prof. Ehrenberg, as to the complexity of organization possessed by the minutest forms of Animalcules, have now been rejected by the concurrent voice of the most competent observers, working with the best instruments, yet the wonders of animalcular life are not in the least diminished by this repudiation of them. Indeed, as great and small are merely relative terms, it may be questioned whether the marvel of a complex structure comprised within the narrowest space we can conceive, is really so great as that of finding those operations of life which we are accustomed to see carried on by an elaborate apparatus, performed without any instruments whatever;—a little particle of apparently homogeneous jelly changing itself into a greater variety of forms than the fabled Proteus, laying hold of its food without members, swallowing it without a mouth, digesting it without a stomach, appropriating its nutritious material without absorbent vessels or a circulating system, moving from place to place without muscles, feeling (if it has any power to do so) without nerves, multiplying itself without eggs, and not only this, but in many instances forming shelly coverings of a symmetry and completeness not surpassed by those of any testaceous animals.

As an example of this type of existence, the *Amœba*, a common inhabitant of fresh waters, may be first selected. This may be described as a minute mass of "sarcode," presenting scarcely any evidence of organization even of the simplest kind; for although its superficial layer has a somewhat firmer consistency than the semifluid interior, this differentiation does not proceed to the extent of constituting even a body so simple as the "cell" of physiologists, which consists of a definite membrane investing and limiting its contents. Although at some times shapeless and inert, the *Amœba* at others is a creature of no inconsiderable activity. Its gelatinous body extends itself into one or more finger-like prolongations; the interior substance transfers itself into one or other of these, distending it until the entire mass is (as it were) carried into it; and then, after a short time, another prolongation is put forth, either in the same or in some different direction, and the body being again absorbed into it, the place of the animal is again changed. When the creature, in the course of its progress, meets with a particle capable of affording it nutriment, its gelatinous body spreads itself over or around this, so as to envelope it completely; and the particle (sometimes animal, sometimes vegetable) thus taken into this extemporized stomach, undergoes a sort of digestion there, the nutrient material being extracted, and any indigestible part making its way to the surface, and being finally (as it were) squeezed out. The *Amœba* multiplies itself by self-division; and portions separated from the jelly-like mass, either by cutting or tearing, can develope themselves into independent beings.

Nearly allied to this is another curious organism, on which the attention of many eminent microscopists has been recently fixed. This creature, the *Actinophrys*, has a body whose form is more constantly spherical, but extends its sarcode into radiating filaments of extreme delicacy, which are termed *pseudopodia*; and it is by the agency of these, rather than by the change of place of its whole body (as in *Amœba*), that it obtains its food. For when any small free-moving animalcule or active spore of a vegetable comes into contact with one of the pseudopodia, this usually retains it by adhesion, and forthwith begins to retract itself; as it shortens, the surrounding filaments also apply themselves to the captive particle, bending their points together so as gradually to enclose it, and themselves retracting until the prey is brought close to the surface of the body. The threads of "sarcode" of which the pseudopodia are composed, not being invested (any more than the sarcode of the body) by any limiting membrane, coalesce with each other and with it; and thus the particle which has been entrapped becomes actually imbedded in the gelatinous mass, and gradually passes towards the central part of it, where its digestible portion undergoes solution, the superficial part of the body with its pseudopodial prolongations in the meantime recovering its previous condition. Any indigestible portion, as the shell of an Entomostracan, or the hard case of a Rotifer, finds its way to the surface of the body, and is extruded from it by a process exactly the converse of that by which it was drawn in.

If, now, it be asked, in what consists the peculiar animality of beings thus destitute of every feature that we are accustomed to associate with the idea of an animal,—that is, if it be inquired what are the characters by which they are distinguished from vegetable organisms of equal simplicity,—the physiologist cannot with confidence reply that sufficient evidence is afforded by the movements of the *Amœba* and *Actinophrys*; since among the lowest Plants there are many, which, at least in certain stages of their lives, are endowed with yet even greater activity. A more positive and satisfactory distinction lies in the nature of their aliment, and in the method of its introduction. For whilst the *protophyte* obtains the materials of its nutrition from the air and moisture that surround it, and possesses the power of detaching oxygen, hydrogen, carbon and nitrogen from their previous binary compounds, and of uniting them into ternary and quaternary organic compounds (chlorophyll, starch, albumen, &c.), the simplest *protozoon*, in common with the highest members of the animal kingdom, seems utterly destitute of any such power, and depends for its support upon organic substances previously elaborated by other living beings. Further, whilst the protophyte obtains its nutriment by simple imbibition, the protozoon, though destitute of any proper stomach, extemporizes, as it were, a stomach for itself in the substance of its body, into which it ingests the solid particles that constitute its food, and within which it subjects them to a regular process of digestion. Hence these simplest members of the two kingdoms, which can scarcely be distinguished from each other by any *structural* characters, seem to be *physiologically* separable by the mode in which they perform those actions wherein their life most essentially consists.

There are found, both in fresh and salt waters, numerous examples of this Rhizopod type, which do not present any essential advance upon the *Amœba* and *Actinophrys*; and a large proportion of these are endowed with a shelly investment which may be either calcareous or siliceous,—the former being the characteristic of the *Foraminifera*, the latter of the *Polycystina*. In some of these testaceous forms, the pseudopodia are put forth only from the mouth of the shell, whilst in other cases this is perforated with minute apertures for their passage; but where there are no such apertures, the sarcode body not unfrequently extends itself over the entire external surface of the shell, and may give off pseudopodia in every direction.

Generally speaking, the Foraminifera live attached to sea-weeds, zoophytes, &c.; but their pseudopodia have a very extensive range, and form a sort of animated spider's-web, most wonderfully adapted for the prehension of food. The absence of any membranous investment to these threads is clearly indicated by their fusion or coalescence when two or more happen to come into contact; and sometimes a fresh expansion of sarcode takes place at spots remote from the body, so as to form new centres from which a fresh radiation of pseudopodia proceeds.

By far the greater number of Foraminifera are *composite* fabrics, evolved, like zoophytes, by a process of continuous gemmation, each *gemma* or bud remaining in connexion with that from which it was put forth; and according to the plan on which this gemmation takes place, will be the configuration of the composite body thereby produced. Where the segments succeed each other in a line, that line is very commonly bent into a spiral; and each new segment being a little larger than the preceding, the spire gradually opens out, so that the shell very closely resembles that of the Nautilus, both in its form and in its chambered structure. There is, however, this essential difference,—that whereas in the Nautilus and other chambered cells formed by cephalopod mollusks, the animal lives only in the outermost chamber, all the inner ones having been successively vacated by it, each chamber in the foraminiferous shell continues to be occupied by a segment of the composite body, communicating with the segments within and without by threads of sarcode, which traverse minute passages left in the partitions between the chambers. In the classification of these forms, an extraordinary amount of allowance has to be made for the very wide range of variation that may present itself within the limits of one and the same specific type. It is very easy to select from any extensive collection of Foraminifera, recent or fossil, sets of forms having certain characters in common, but yet so dissimilar in other respects that few naturalists would have any doubt as to their specific or even generic distinctness; yet when the collection is thoroughly examined, such a series of intermediate forms is found to exist, as connects all these by gradations so insensible as to prevent the possibility of any line of demarcation being satisfactorily drawn between them. A remarkable example of this kind is presented by the generic types designated as *Dendritina* and *Peneroplis*; the former being a minute shell, resembling that of the Nautilus in its general proportions, and having a single large dendritic aperture in its successive partitions; whilst the latter is flattened, and instead of one large aperture, has a series of small foramina arranged in a single line. Now between these every gradation can be found, both in the form of the shell and in the mode of communication through the septa; the flattened shell of *Peneroplis* presenting various degrees of turgidity until it attains the proportions of *Dendritina*; and the linear arrangement of the isolated apertures, in like manner, giving place to one in which they are approximated more closely together into a sort of bundle, still, however, retaining their distinctness; whilst in other individuals, the distinct apertures coalesce into one large jagged orifice, the borders of which become more and more deeply cut, until they present the ramifying extensions characteristic of *Dendritina*. Now, if, in such a series, we once begin to make a distinct species for every well-marked dissimilarity, either in the form of the shell, or in that of the aperture, we must multiply our species almost indefinitely, contrary to all probability; and there is no medium between doing this, and uniting the whole series of forms included in these two reputed genera under one specific type. This is the more remarkable, because in one locality we may find only the Dendritina-form, in another only the Peneroplis-form, whilst the transitional or intermediate forms come from a third.

Another remarkable example of this wide range of specific characters is presented in the *Orbitolite*, a composite organism, which, originating in a spheroidal nucleus of sarcode, increases by the formation of new segments in concentric rings around this, so that, each segment becoming invested with a shelly envelope, a very beautiful disk is formed, which is enlarged by successive additions to its margin. The segments communicate with each other by annular canals; and there are also passages connecting each annulus with those within and without; whilst from the outermost annulus there are passages opening at the margin of the shelly disk, through which alone the pseudopodia issue that obtain the food for the whole organism. Now there are two very distinct types of growth presented by these Orbitolites: one, namely, in which the disk is very thin, and the segments form (as it were) but a single floor; and the other in which the disk becomes comparatively thick through the vertical elongation of the segments, which, moreover, are themselves partially divided into at least three distinct stories; two, namely, which form the two surfaces of the disk, and an intermediate one, which is very distinctly separated from them both. The former type of growth may be designated as the *simple*, the latter as the *complex*. Now some Orbitolites seem to go through their whole lives upon the simple plan, whilst in others the complex plan shows itself in the very first ring; and from the comparison of such alone, it might be fairly supposed that these two plans are characteristic of two distinct species. But when a considerable number of these forms are examined, it appears that the simple type may pass into the complex at any period of its growth; the same disk presenting the simple plan in the first 5, 10, 20, 30, or more annuli, and the complex in all those subsequently formed. Hence there can be no question that even so marked a diversity in plan of growth is not in that case sufficient to establish a diversity of specific type, but that the two must be accounted varieties only.

A no less remarkable range of variation has been shown by Professor Williamson and Mr. W. K. Parker to prevail in other groups of Foraminifera which they have particularly studied; so that it would appear as if this type of animal existence were specially characterized by its tendency to such variations. And this will seem the more probable, when it is considered how little of definiteness there is in the form and structure of the sarcode body that forms the shell; so that the wonder is, not that there should be a wide range of variation both in the form and in the plan of growth of the aggregate body, and in the mode of communication of the individual segments, but that there should be any regularity or constancy whatever. But it is only in the *degree* of this range that this group differs from others; and the main principle which must be taken as the basis of its systematic arrangement,—that of ascertaining the range of specific variation by an extensive comparison of individual forms,—is one which finds its application in every department of natural history, and is now recognized and acted on by all the most eminent zoologists and botanists. There are still too many, however, who are far too ready to establish new species upon variations of the most trivial character, without taking the pains to establish the value of these differences by ascertaining their constancy through an extensive series of individuals,—thus, as was well said by the late Prince of Canino, "describing specimens instead of species," and burdening science not only with a useless nomenclature, but with a mass of false assertions. It should be borne in mind that every one who thus makes a bad species, is really doing a serious detriment to science; whilst every one who proves the identity of species previously accounted distinct, is contributing towards its simplification, and is therefore one of its truest benefactors.

Some of the most interesting physiological and zoological considerations which connect themselves with the study of this group having thus been noticed, its geological importance has in the last place to be alluded to. Traces, more or less abundant, of the existence of Foraminifera are to be found in calcareous rocks of nearly all geological periods; but it is towards the end of the Secondary, and at the beginning of the Tertiary period, that the development of this group seems to have attained its maximum. Although there can be no reasonable doubt that the formation of Chalk is partly due to the disintegration of corals and larger shells, yet it cannot be questioned that in many localities a very large proportion of its mass has been formed by the slow accumulation of foraminiferous shells, sometimes preserved entire, sometimes fragmentary, and sometimes almost entirely disintegrated. The most extraordinary manifestation of this type of life, however, presents itself in the "nummulitic limestone," which may be traced from the region of the Pyrenees, through that of the Alps and Apennines, into Asia Minor, and again through Northern Africa and Egypt, into Arabia, Persia, and Northern India, and thence (it is believed) through Thibet and China, to the Pacific, covering very extensive areas, and attaining a thickness in some places of many thousand feet: another extensive tract of this nummulitic limestone is found in the United States. A similar formation, of less extent, but of great importance, occurs in the Paris basin; and it is not a little remarkable that the fine-grained and easily-worked limestone, which affords such an excellent material for the decorated buildings of the French metropolis, is entirely formed of an accumulation of minute foraminiferous shells. Even in the nummulitic limestone, the matrix in which the Nummulites are imbedded is itself composed of minute Foraminifera, and of the comminuted fragments of larger ones. The remarkable discovery has been recently made by Prof. Ehrenberg, that the green and ferruginous sands which present themselves in various stratified deposits, from the Silurian to the Tertiary epoch, but which are especially abundant in the Cretaceous period, are chiefly composed of *casts* of the interior of minute shells of Foraminifera and Mollusca, the shells themselves having entirely disappeared. The material of these casts, which is chiefly silex, coloured by silicate of iron, has not merely filled the chambers and their communicating passages, but has also penetrated, even to its minutest ramifications, that system of interseptal canals, whose existence, first discovered by Dr. Carpenter in Nummulites, has been detected also in many recent Foraminifera allied to these in general plan of structure. And it is a very interesting pendent to this discovery, that a like process has been shown by Prof. Bailey to be at present going on over various parts of the sea-bottom of the Gulf of Mexico and the Gulf Stream; casts of Foraminifera in green sand being brought up in soundings with living specimens of the same types.

MISCELLANEOUS.

Obituary Notice.—Robert Brown, Esq.

Died at his residence, 17 Dean Street, Soho Square, formerly the library of Sir Joseph Banks, on the 10th of June, Robert Brown, Esq., D.C.L., F.R.S., Keeper of the Botanical Collections in the British Museum, and formerly President of the Linnæan Society. We translate from the 'Archives de Botanique' for April 1833, the following notice of this great botanist, from the pen of M. Adrien de Jussieu:—

"The Academy of Sciences of the Institute of France reckons among its members eight foreign associates. Whenever death effaces one of these eight names, the name which appears most illustrious in the world of science out of France is designated to replace it. To read over the list of the foreign associates of the Academy from its foundation, is consequently to pass in review all those men whose memory is connected with the history of the great advances of the human mind,—Newton, Leibnitz, Euler, Linnæus, Haller, Volta, &c. The science which we cultivate may therefore be proud of the fact that, at this moment, of the eight elected from among the luminaries of science, two are botanists, M. DeCandolle and Mr. Brown.

"It was in the sitting of the 4th of March that Mr. Brown was elected by the Academy. Of 47 votes he obtained 29; the remainder were shared among his competitors, none of whom had more than 7 votes. They were Bessel, Von Buch, Faraday, Herschel, Jacobi, Meckel, Mitscherlich, Œrsted, and Plana. That among so